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(54) Method for generating graphical models and computer aided design system.

(57) A computer aided design system generates graphical models of 2- or 3-dimensional objects with at least partially variable dimensions, in particular mechanical parts. In order to generate models having a predetermined plurality of structural elements, like through-holes, etc. being distributed over the model in a predetermined manner, the computer aided design system is provided with means for selecting a sub-group of design commands corresponding to a structural element of the model. After inputting of a replication command, the selected element is replicated in a predetermined manner, e.g. distributed either by rotation about a predetermined center point at predetermined angular steps or shifted along linear axes with predetermined spacings or scaled at predetermined locations.

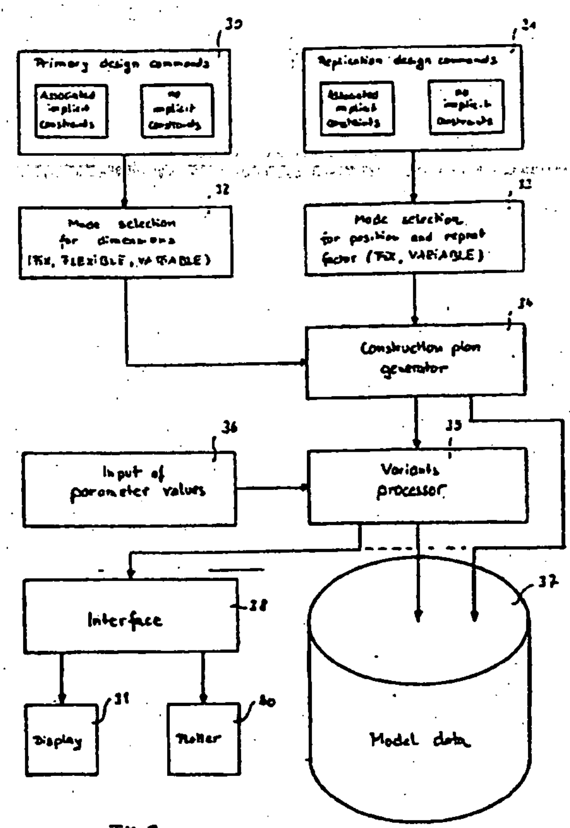

FIG.7

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METHOD FOR GENERATING GRAPHICAL MODELS AND COMPUTER AIDED DESIGN SYSTEM

This invention relates to a method for generating graphical models of 2- or 3-dimensional objects with at least partially variable dimensions, in particular mechanical parts, in a computer aided design system, comprising a set of design commands.

This invention, further, relates to a computer aided design system, comprising at least one user input interface, preferably a keyboard and/or a graphics tablet, further comprising at least one user output interface, preferably a screen with graphics capabilities and/or a plotter, and, further, comprising a digital processor being connected with said user input interface and said user output interface, and with a program memory containing instructions to operate said digital processor.

A method and a system of the aforementioned kind are described in European patent application 88 109 628.3, being prior art in view of Article 54(3) EPC.

The aforementioned European patent application 88 109 628.3 of the same applicant discloses various details of computer aided design methods and systems, and the disclosure of that application is herewith incorporated into the present application by reference.

A computer aided design system is used to build graphical models and graphical drawings of mechanical parts in an interactive mode, i.e. to enter a geometry and its dimensions by well-known input means such as keyboards, graphic tablets, mouses, etc., to show these parts on a high-resolution CRT and finally to plot them. A common technique is to enter fix values for the dimensions of a mechanical part to be drawn. Still this technique has the disadvantage that it is rather uncomfortable to alter the dimensions in a later stage of the design process.

One has, therefore, already tried to build CAD systems which allow to enter variable dimensions, i.e. to enter a symbolic value or label for certain dimensions during the design process and to replace it - in a second step - by an actual dimension in order to create the actual part.

CAD systems which allow the input of symbolic dimensions are particularly important for the creation of part families, i.e. of parts with principally the same shape, but differing dimensions. They are further used for the design of parts, the dimentions of which are not yet finally defined.

The above-mentioned European patent application 88 109 628.3 discusses various prior art methods and systems, e.g. the method of variant programming, the interactive variant design with sequential calculation of the geometrical points of a variant and the interactive variant design with simultaneous calculation of the geometrical points.

These prior art techniques are, e.g., described in "HP-DESIGN, HP7 98355A, Technical Description, November 1984", in the book of Light, R. and Gossard, D.: MODIFICATION OF GEOMETRIC MODELS THROUGH VARIATIONAL GEOMETRY, Computer Aided Design, Volume 14, July 4, 1982, Butterworth & Co. Ltd., and, further, in a Master Thesis of Chyz, G.W. "CONSTRAINT MANAGEMENT FOR CONSTRUCTIVE GEOMETRY", Department of Mechanical Engineering, MIT, 1985." Further prior art computer aided design methods and systems are described in an article of Gossard, D.C., R. P. Zuffante and H. Sakurai, entitled "REPRESENTING DIMENSIONS, TOLERANCES, AND FEATURES IN MCAE SYSTEMS", published in US-Z-IEEE Computer Graphics and Applications, March 1988.

Considering the disclosure of European patent application 88 109 628.3, one can conclude that the problem of interactive design with dimensional parameters is adequately solved. However, recent progress in design methodologies for CAD systems brought a new aspect to the problem of parametric design. More precisely, there is a need for future CAD systems supporting the design process with high-level form features such as hole patterns, hinges, complex through holes, etc., as opposed to simple geometric primitives like points, lines, surfaces and elementary bodies. A survey on this high-level form feature design is given in a Report of J. Shah, entitled "CURRENT STATUS OF FEATURES TECHNOLOGY", Report No. R-88-GM-04.1, CAD-I Computer Aided Manufacturing International, Arlington, TX, 1988.

It is, therefore, an object of the present invention to make CAD systems more intelligent with respect to the support of design decisions, particularly by providing an interactive generation of parametric designs with structural parameters in addition to dimensional parameters.

According to the method, explained at the outset, this object is achieved by the steps of

- selecting a sub-group of geometric elements or of design commands therefore corresponding to a structural element of said model;
- inputting a replication command;
- replicating said design commands to generate a model being provided with a plurality of said replicated structural elements.

According to the system, explained at the outset, the object is achieved in that

- said user input interface comprises a set of design command entry means, preferably keys of

said graphic tablet which are logically divided into at least two sub-groups

– in the first sub-group each command being associated with a primary design feature;

– in the second sub-group each command being associated with a replication feature;

- said program memory contains instructions

– to select a sub-group of geometric elements or of design commands therefore corresponding to a structural element of said model;

– to replicate said geometric elements or said design commands therefore to provide a model being provided with a predetermined plurality of said replicated structural elements.

The invention, therefore, results in a tremendous effectivity increase in interactive design with CAD systems since significantly more particular designs can be generated automatically out of a generic design.

In a preferred embodiment of the method according to the invention, said replication command comprises a rotation command for arranging said plurality of structural elements in a rotational distribution about a predetermined center point in predetermined angular steps.

These features have the advantage that rotational parts like wheels, etc. may be easily modified in an interactive manner by increasing the number of e.g. eccentric gaps, mounting holes, etc. by just distributing a predetermined plurality of the aforementioned elements about an inner or outer periphery of the wheel without the necessity of entirely redesigning any of these variants.

In another similar embodiment of the method according to the invention, said replication command comprises a shift command for arranging the plurality of structural elements in a linear distribution along a predetermined axis in predetermined spacings. Preferably, said axis is a horizontal or vertical axis.

Again, these features offer the advantage to easily modify a model having larger dimensions either in a horizontal or vertical direction by increasing the number of e.g. through-holes or gaps, possibly according to certain design rules in an automatic way.

Still according to another similar preferred embodiment of the invention, said replication command comprises a scaling command for arranging said plurality of structural elements in a predetermined distribution at predetermined locations in predetermined scalings.

These features, too, offer the advantage of easily modifying a given model by distributing the aforementioned structural elements in different scalings at any conceivable locations.

According to further preferred embodiments of the method according to the invention, design commands are executed either in a fixed mode in which the number of replications to be performed as well as their locations are fixed, or in a variable mode in which the number of replications to be performed as well as their locations are given as variables, or a combination thereof.

These features known per se from the above-mentioned European patent application 88 109 628.3 offer the advantage to either simplify the method by predetermining fixed values or by offering additional design perspectives in that the replication mode is made variable.

Seen as a whole, the method and the system according to the invention offer substantial advantages to the user by saving time for complex construction objects. This stems from the invented principle of interactive generation of a generic design with unlimited (variable) numbers of structural elements as well as variable positions of such elements.

In a given example of a wheel with a predetermined number of gaps, as will be described below in connection with the drawings, a comparison was made with prior art techniques. In order to program the aforementioned example in a high-level language, a medium-experienced user typically would need about 4 hours. With an interactive dimension-driven CAD system based on prior art technology, this example cannot be carried out at all, because the maximum number of eccentric holes that might appear in practice later on is not known at the time of doing the master design. However, assuming as an example the maximum number of holes to be 36, the 36 eccentric holes would have to be designed explicitly with distinguished dimension variables. This then would allow to set paramaters to zero for an arbitrary number of the designed eccentric gaps and, thus, produce variants with different numbers of gaps. The design time in this case, in spite of the limited flexibility of the number of gaps - still is about 3 hours. With the method and the system according to this invention, the complete design takes only about 10 minutes. As can be seen, the method and the system according to the invention can boost-up the efficiency of a parametric design system by orders of magnitudes and, thus, save enormous costs in the design phase.

It goes without saying that all of the features, discussed hereinbefore or hereinafter, may not only be used in the particular combination as described but, also, in other combinations, or alone without leaving the scope of the present invention.

The accompanying drawings depict preferred embodiments of the present invention. In particular, further features and advantages of the invention may be apparent in this detailed description. In the drawings,

Figs. 1 to 3 illustrate how dimensional changes relate to the topological structure in prior art systems;

Figs. 4 to 6 illustrate various examples of structural design changes;

Fig. 7 shows a block diagram illustrating the architecture of a system according to the invention;

Fig. 8 shows a flow diagram for a replication design command;

Fig. 9 shows a design example of a wheel with eccentric gaps;

Figs. 10 and 11 show generic variants of the example of Fig. 9.

Fig. 1A shows a first planar design 10 of essentially rectangular shape with a gap 11 being arranged on the upper margin and having a rectangular shape, too. The respective dimensions are referred to as A, B, and C. If dimension B is now modified into B′ as depicted by modified planar design 10′ in Fig. 1B, the configuration may become unrealistic if B′ becomes equal 2 or greater than the sum of B and C, as can clearly be seen in Fig. 1B at 12.

Another example of topology consequences as a result of dimensional changes is depicted in Fig. 2A with a second planar design 13 of rectangular shape being provided with a circular hole 14 at a distance A from the left margin. If dimension A is modified in A′ as depicted in Fig. 2B by modified planar design 13′, then it may be that the hole 14′ is caused to be outside of design 13.

Turning now to Fig. 3; Fig. 3A shows a third planar design 15 with a gap 16 similar to gap 11 of Fig. 1A and with same dimensions A, B, and C.

If dimension B′ is modified as shown in Fig. 3B with modified planar design 15′, implicit constraints and dimensions are now in contradiction to topology, as shown at 17 in Fig. 3B, if the bottom line of third planar design 15 or 15′, respectively, is made of fixed length instead of interconnecting two given points.

Frequently, functional requirements for a design do not only determine the dimensions of a geometric design but also the structure of a design. In these cases, structural as well as dimensional parameters are needed to describe the design.

Fig. 4A and 4B show a first example of a fourth planar design 20 and 20′, respectively, where unmodified planar design 20 is provided with four holes 21, distributed along a quadrangle.

Modified planar design 20′ of Fig. 4B instead shows six holes 21′ as may be the case when through-holes in a plate (for fixture) depend on the size of the plate.

A second example is shown in Figs. 5A and 5B, respectively, with a spring 22 in Fig. 5A of length L being modified into spring 22′ of Fig. 5B with modified length L′, if the number of windings of the spring 22, 22′ depends on the specific load requirements.

A third example is shown in Figs. 6A and 6B, respectively, with a fifth planar design having a circular set of thread holes as is the case e.g. in a gear-box dependent on the fastening configuration in the assembly.

Whereas three circularly distributed holes 24 are used in planar design 23 of Fig. 6A, six such circularly distributed holes 24′ are used in modified planar design 23′ of Fig. 6B.

With prior art systems in the cases of Figs. 4 through 6, all particular designs either needed to be designed explicitly or a program had to be written by the user that captures the generic design and generates the particular design according to input parameters.

The employment of interactive dimension-driven CAD systems that only support the design with dimensional parameters is rather awkward and only possible in some special cases. It would require that the master model covers the most complex structural configuration. For the generation of variants, dimensions of unwanted structural elements will need to be set to zero. It is obvious that the explicit design of the most complex situation is rather time-consuming. However, an even bigger problem is the fact that often the maximum structure is not known up-front at all.

According to the present invention, a new method and system is used that supports the design of dimensional as well as structural variants in a graphically interactive manner. The architecture of a system based on this method is shown in Fig. 7.

The method and system according to the present invention employs two main sets of design commands. As identified in Fig. 7 by reference numerals 30 and 31, the invention employs primary design commands as well as replication design commands. Both commands may be inputted into a computer aided design system according to the present invention by means of an user input interface, e.g. a conventional keyboard and/or a graphics tablet. For the purpose of the present example, it may be assumed that it is a graphics tablet.

The graphics tablet comprises a set of keys which are used to enter design commands, i.e. by pressing an appropriate pen on predefined areas of the graphics tablet. Other keys may be used for further functions, e.g. HELP, PLOT, etc., as described in further detail in co-pending European patent application 88 109 628.3.

In the present invention, the primary design commands support the initial design of geometric elements. These commands are comparable to the design commands, as explained in further detail in co-pending European patent application 88 109

628.3. They can be divided into two sub-classes, one that relates implicit dimensional constraints (e.g. LINE_HORIZONTAL, LINE VERTICAL, LINE_PARALLEL, etc.) to the command, and another one that does not impose any implicit dimensional constraints by the use of a command (e.g. LINE_BETWEEN_TWO_POINTS). All of the commands in both sub-classes can be executed in the modes FIX, FLEXIBLE, or VARIABLE, as identified by reference numerals 32 and 33 in Fig. 7. In FIX mode, the command will generate a geometric element with fixed dimensions. The VARIABLE mode associates variables to the dimensions of the created elements. Variables with consecutive indices can be generated automatically at the time of performing a primary design command in VARIABLE mode. Eventually, the FLEXIBLE mode generates elements that fit between two existing points (as e.g. was not the case in the representation of Fig. 3B). In this case, the dimensions are determined implicitly.

The replication design commands, as represented by reference numeral 31 in Fig. 7, on the other hand, are used to design geometric elements or groups of elements that have multiple occurrences in the design. Examples of replication design comands are:

ROTATE: This command generates multiple copies of a set of selected geometric elements and places them in a circular configuration with specified angles and distances from a center point.

COPY_HORIZONTAL: This command generates multiple copies of a selected set of geometric and/or annotation elements with specified distances along a horizontal direction.

COPY_VERTICAL: In an analogous way this command generates multiple copies in a vertical direction. It goes, however, without saying that the direction of shifting multiple copies of the selected set of elements may also be other than 90 degrees or 0 degrees with respect to the horizontal or vertical axis, respectively.

SCALE: performs the generation of multiple scaled copies of selected geometric elements at specific locations.

The replication design commands can be executed either in a FIX mode or a VARIABLE mode, as can be seen at reference numeral 33 in Fig. 7 and similar to the primary design commands at 32 in Fig. 7. In the FIX mode, the number of replications that are being performed by the command are fixed as well as the positions for the generated replications. In VARIABLE mode, variables are generated and associated to the number of replications as well as to the position parameters. Of course, mixed modes could also be supported.

During a design session, all design commands used are sent as input to a construction plan generator 34. The construction plan generator 34 is a program that generates a generic design as an output. This generic design consists of a sequence of design commands where repeat factors and all geometric points are stored using variables. This also includes points of geometric elements that have been generated in FIX mode since FIX mode only imposes fixed dimensions to elements but not fixed locations.

From a generic design, variants can be generated through a variants processor 35 according to specific parameter values. The variants processor 35 essentially consists of routines that are already existing in conventional CAD systems. It replaces the variables by the actual values as inputted at 36 and performs a sequence of elementary design commands. The production of variants is very fast, because the construction plan includes the complete set of necessary operations in the proper sequence. In fact, the generation of a variant is done in about the time an infinitely fast user would need to input the design.

The entire set of data generated are now stored as model data 37 in Fig. 7 and are, in parallel, fed to an interface 38 for representing the generated design on a display 39, e.g. a graphic CRT or may be printed out on a conventional plotter 40.

Fig. 8 is a simplified representation of a flow diagram for a replication design command on the example of ROTATE. After inputting the replication command which may comprise one or more replication functions, and selecting the VARIABLE or FIX mode, the various replication design functions may be selected like MOVE_HOR, MOV_VER, SCALE, or inter alia, ROTATE. In the latter case, a REPEAT_FACTOR is to be selected representing the number of copies which are to be arranged about a common CENTER POINT, each at a predetermined ANGLE, the latter being also commands which are to be inputted in order to perform the ROTATE replication design command.

Of course, the selection of FIX or VARIABLE mode could be done also for each replication design command separately. Commands that perform similar operations to the above described replication design commands in FIX mode already exist in conventional CAD systems. However, they do not impose any implicit constraints to the created data and do not provide the possibility to change any parameters after being used. Therefore, they are of no use for interactive structural and dimensional parametric design. The similarity of existing commands for rigid design makes a parametric system based on the proposed method very easy to use and learn, particularly for users that are already familiar with a conventional CAD system.

Fig. 9 shows an example to demonstrate the

design according to the method and system of the present invention step by step on the example of a wheel 45.

First, a center hole 50 and an outer contour 51 of the wheel 45 are created using primary design commands in VARIABLE mode. The corresponding variable radii are R_1 and R_2.

In the next step, an eccentric gap 52/1 is designed in the wheel 45. The complete design will include an arbitrary number of such eccentric gaps 52, placed at locations with a given but variable offset to the center. However, one explicitly designs only the first gap 52.1 and then use the replication design command ROTATE to create a variable number of, say, two replications 52/2, 52/3 at locations defined by a location parameter.

As a preparation for the creation of the geometry elements for the first gap 52/1, one designs a construction circle 53 with radius R_3 concentric to the outer contour 51 with radius R_1.

Construction geometry elements are unbound lines and are created using primary design commands. They are shown as dotted lines in Fig. 9. Then, two straight construction lines 54, 55 with angles A_1 and A_1 + A_DEL in respect to a horizontal plane 56.

Now, construction circles 56, 57, and 58 are drawn to support the variable fillet radii R_4 and R_5. These construction circles 56 through 58 are placed tangential to the before generated construction elements 53, 54, and 55. After the placement of the construction elements 53 through 58, and OVERDRAW command to draw the contour of the eccentric gap 52 based on the construction line of elements 53 through 58 is used. The lines created with the OVERDRAW command are determined by the intersection points of the construction lines of elements 53 through 58. Therefore, they are stored as flexible lines.

In the next step, the replication design command ROTATE is performed. In more detail, this command is performed with the following inputs (c.f. Fig. 8):

- REPLICATION
- VARIABLE
- ROTATE, repeat factor
- CENTER, fix point, angle
- SELECT, elements

The expressions in capital letters hereby denote command keystrokes, whereas the attributes attached and separated by commas are additional inputs, needed to specify the action. The value for the repeat factor variable has been choosen to be three in the generic design. As a result, we now have the design complete as it is shown in Fig. 9. The parameters that have been created during the above described interactive design session are:

- dimensional parameters: R_1, R_2, R_3, R_4, A_1, A_DEL
- structural parameters: N_1, RA_1

where N_1 is the number of replications (including the first generated design) and RA_1 is the angle of rotation between the first generated design and the second, copied design and, consecutively, any further copied design.

Fig. 9, further, shows interactive graphic elements, namely constraint icons for indicating constraints as e.g. indicating that outer contour 51 and construction circle 53 are concentric and that the contour of eccentric gaps 52 have to fit between connection points (of construction elements 53 through 58). These icons are placed automatically as a graphical feedback for the user about the imposed constraints.

Figs. 10 and 11 show to variants of the design for given sets of parameters.

In Fig. 10, a wheel 60 is provided with two eccentric gaps 61/1 and 61/2, respectively, with the parameters specified on the right margin of Fig. 10.

In contrast, a wheel 65 is provided with eight eccentric gaps 70/1 through 70/8 with the dimensional and structural parameters as also specified on the right margin of Fig. 11.

It goes without saying that "geometric" or "geometric element" in the sense of this application comprises elementary geometric elements like dots, lines, circles, etc. as well as annotations like hatchings, alphanumeric symbols, words, surface quality symbols, etc.

Claims

1. Method for generating graphical models of 2- or 3-dimensional objects with at least partially variable dimensions, in particular mechanical parts, in a computer aided design system, comprising a set of design commands, characterized by the steps of:

(1.1) selecting a sub-group of geometric elements or of design commands therefore corresponding to a structural element of said model;

(1.2) inputting a replication command;

(1.3) replicating the design commands to generate a model being provided with a plurality of said replicated structural elements.

2. The method of claim 1, characterized in that said replication command comprises a rotation command for arranging said plurality of structural elements in a rotational distribution about a predetermined center point in predetermined angular steps.

3. The method of claim 1 or 2, characterized in that said replication command comprises a shift command for arranging said plurality of structural elements in a linear distribution along a predeter-

mined axis in predetermined spacings.

4. The method of claim 3, characterized in that said axis is a horizontal or a vertical axis.

5. The method of claim 1, characterized in that said replication command comprises a scaling command for arranging said plurality of structural elements in a predetermined distribution at predetermined locations in predetermined scalings.

6. The method of any of claims 1 through 5, characterized in that said design commands are executed in a fixed mode in which the number of replications to be performed as well as their locations are fixed.

7. The method of any of claims 1 through 5, characterized in that said design commands are executed in a variable mode in which the number of replications to be performed as well as their locations are given as variables.

8. Computer aided design system comprising:
(8.1) at least one user input interface (30, 31), preferably a keyboard and/or a graphics tablet;
(8.2) at least one user output interface, preferably a screen (31) with graphics capabilities and/or a plotter (40);
(8.3) a digital processor (34, 35) being connected with said user input interface (30, 31) and said user output interface (39, 40) and with a program memory containing instructions to operate said digital processor (34, 35);
characterized in that,
(8.4) said user input interface (30, 31) comprises a set of design command entry means, preferably keys of said graphic tablet which are logically divided into at least two sub-groups
(8.4.1) in the first sub-group each command being associated with a primary design feature;
(8.4.2) in the second sub-group each command being associated with a replication feature;
(8.5) said program memory contains instructions
(8.5.1) to select a sub-group of geometric elements or of design commands therefore corresponding to a structural element of said model;
(8.5.2) to replicate said geometric elements or said design commands therefore to generate a model being provided with a predetermined plurality of said replicated structural elements.

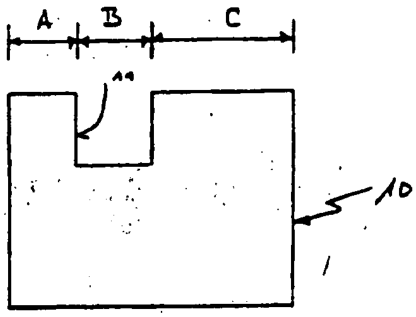


FIG. 1A

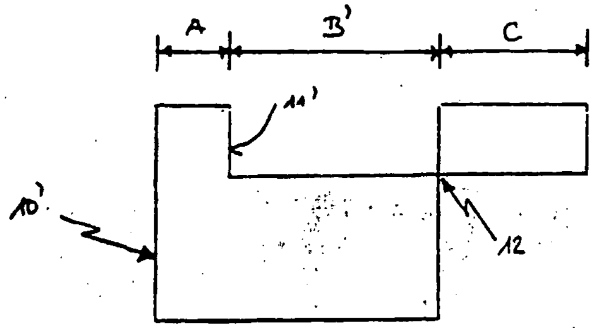


FIG. 1B

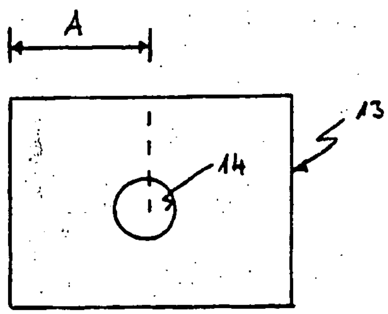


FIG. 2A

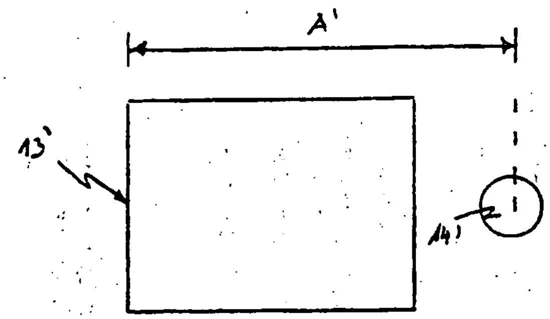


FIG. 2B

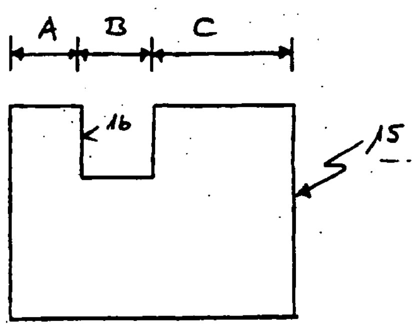


FIG. 3A

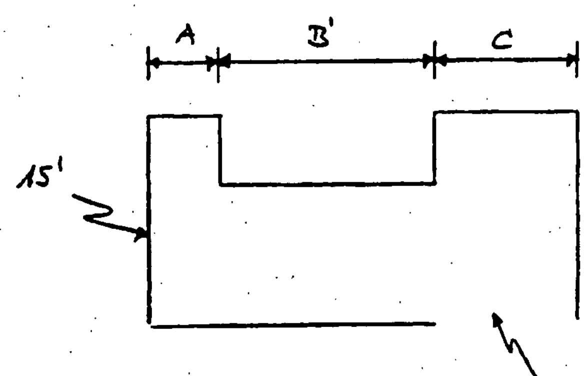


FIG. 3B

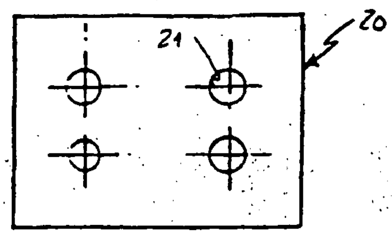


FIG. 4A

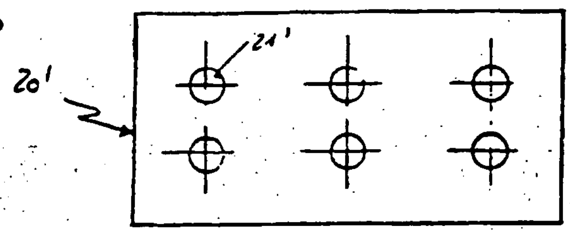


FIG. 4B

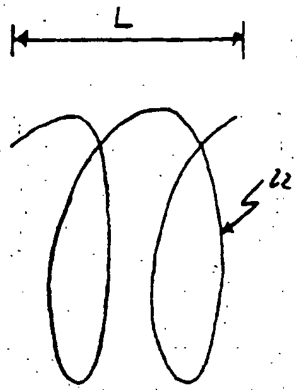


FIG. 5A

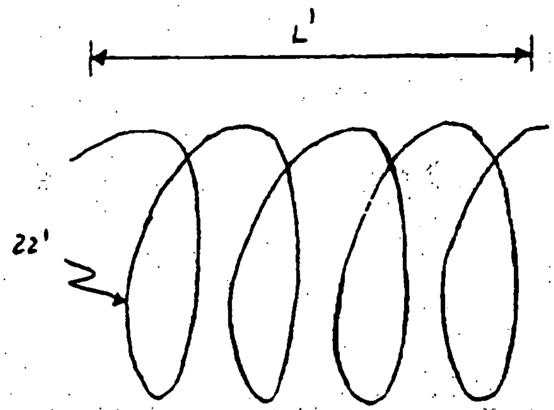


FIG. 5B

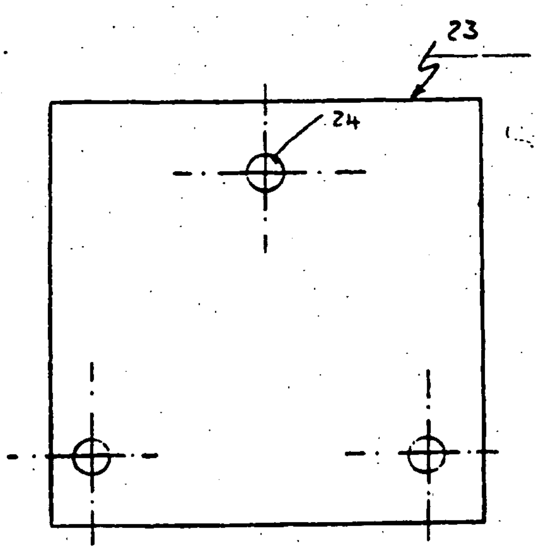


FIG. 6A

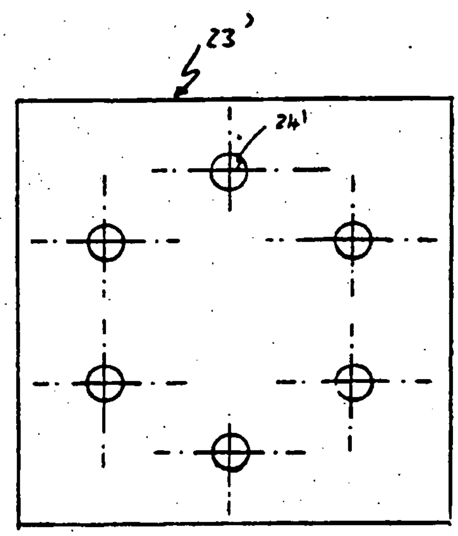


FIG. 6B

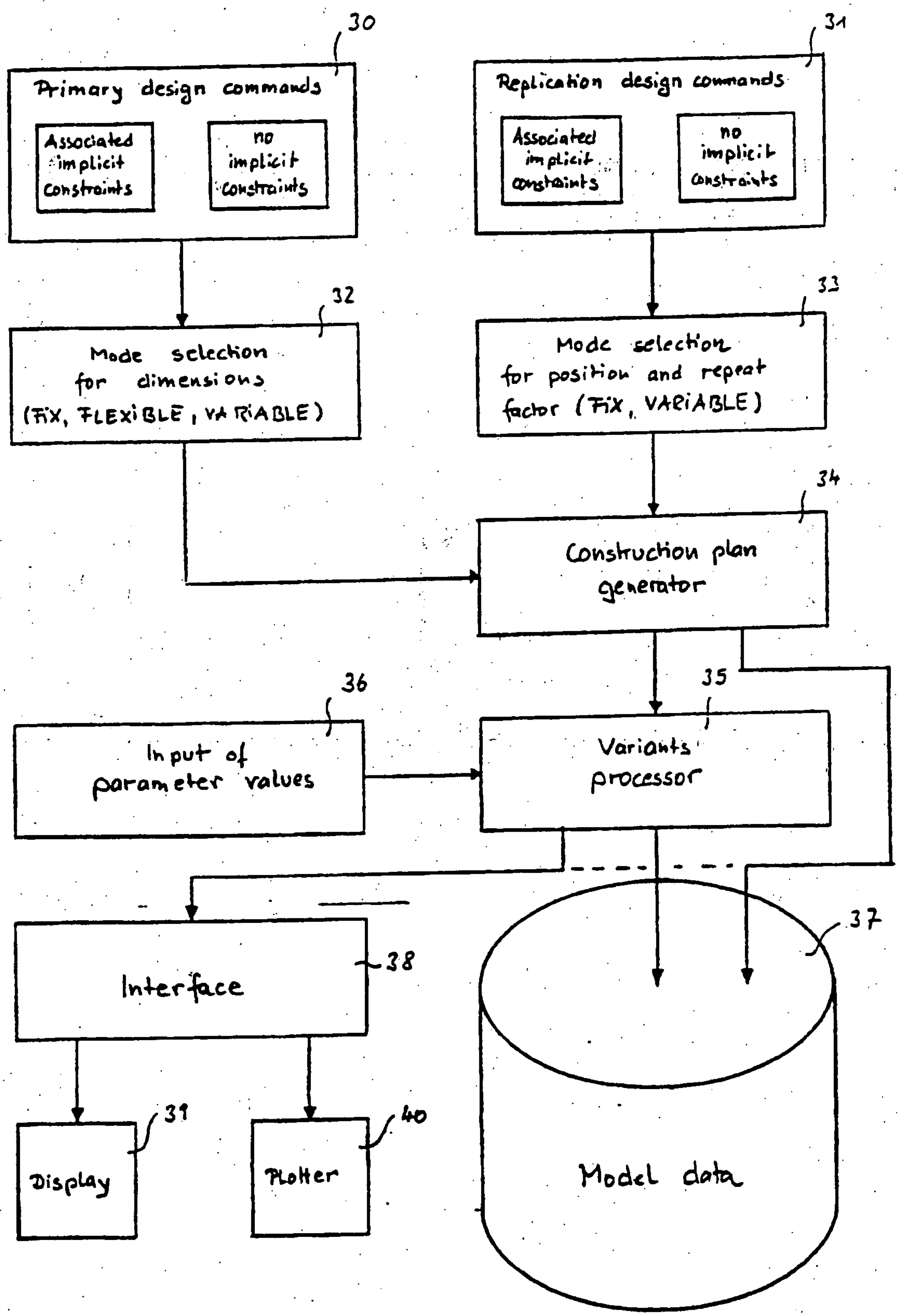
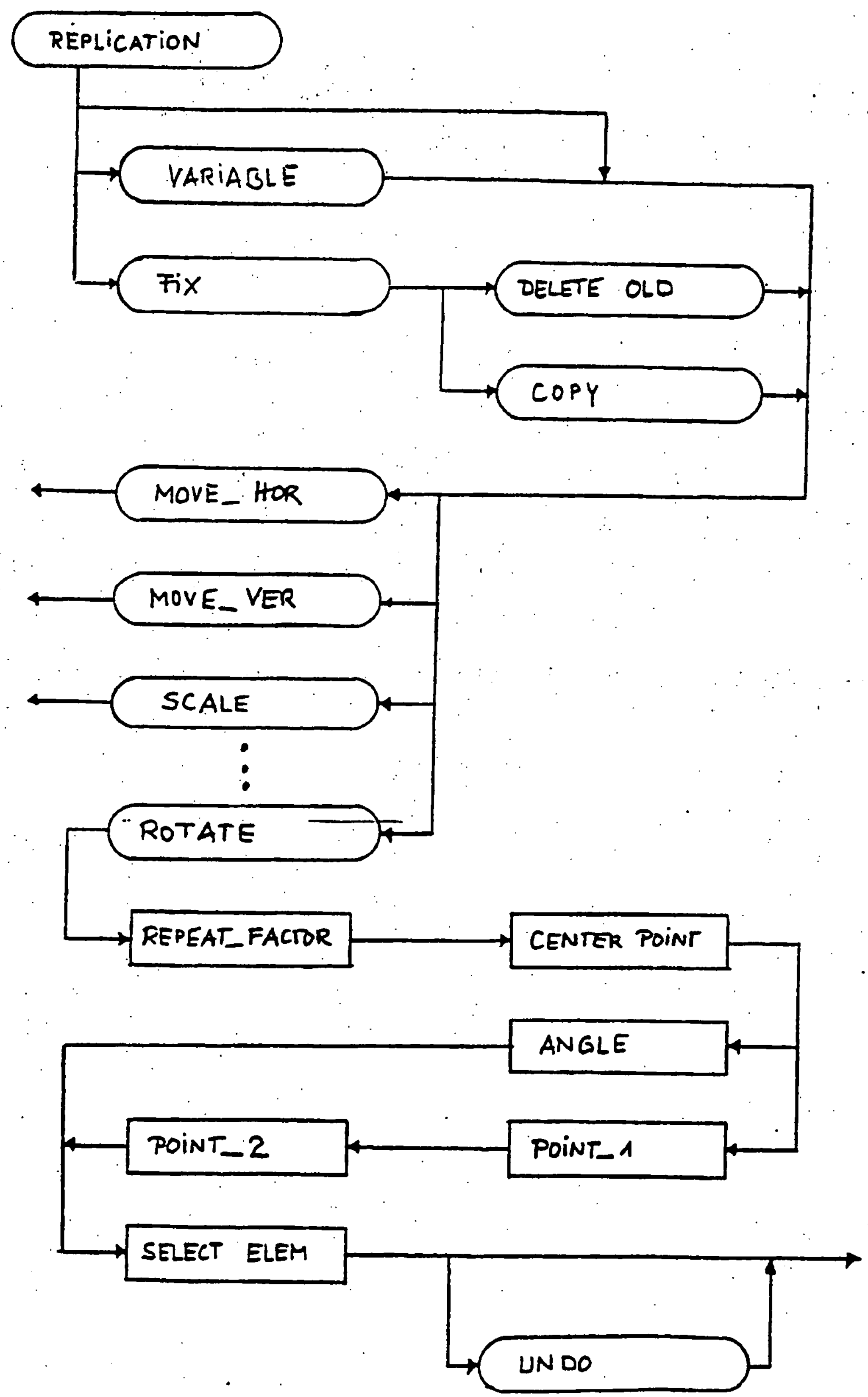

30
Primary design commands
Associated implicit constraints
no implicit constraints
31
Replication design commands
Associated implicit constraints
no implicit constraints
32
Mode selection for dimensions (FIX, FLEXIBLE, VARIABLE)
33
Mode selection for position and repeat factor (FIX, VARIABLE)
34
Construction plan generator
36
Input of parameter values
35
Variants processor
37
38
Interface
39
Display
40
Plotter
Model data

FIG. 7

FiG.8


REPLICATION
VARIABLE
FIX
DELETE OLD
COPY
MOVE_HOR
MOVE_VER
SCALE
ROTATE
REPEAT_FACTOR
CENTER POINT
ANGLE
POINT_2
POINT_1
SELECT ELEM
UNDO

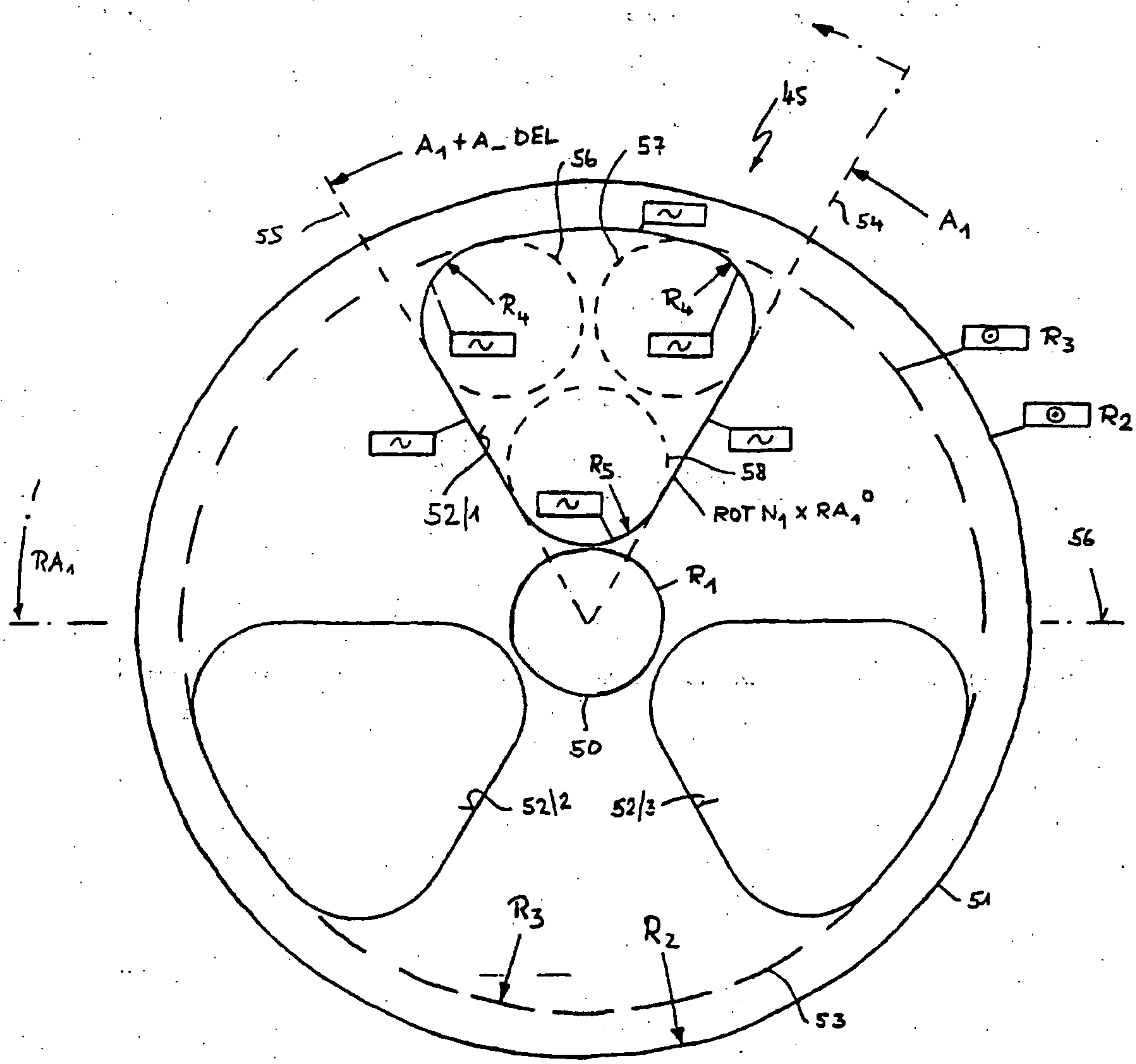


FIG. 9

Constraint icons:

⊙ = concentric

∾ = fit between connection points

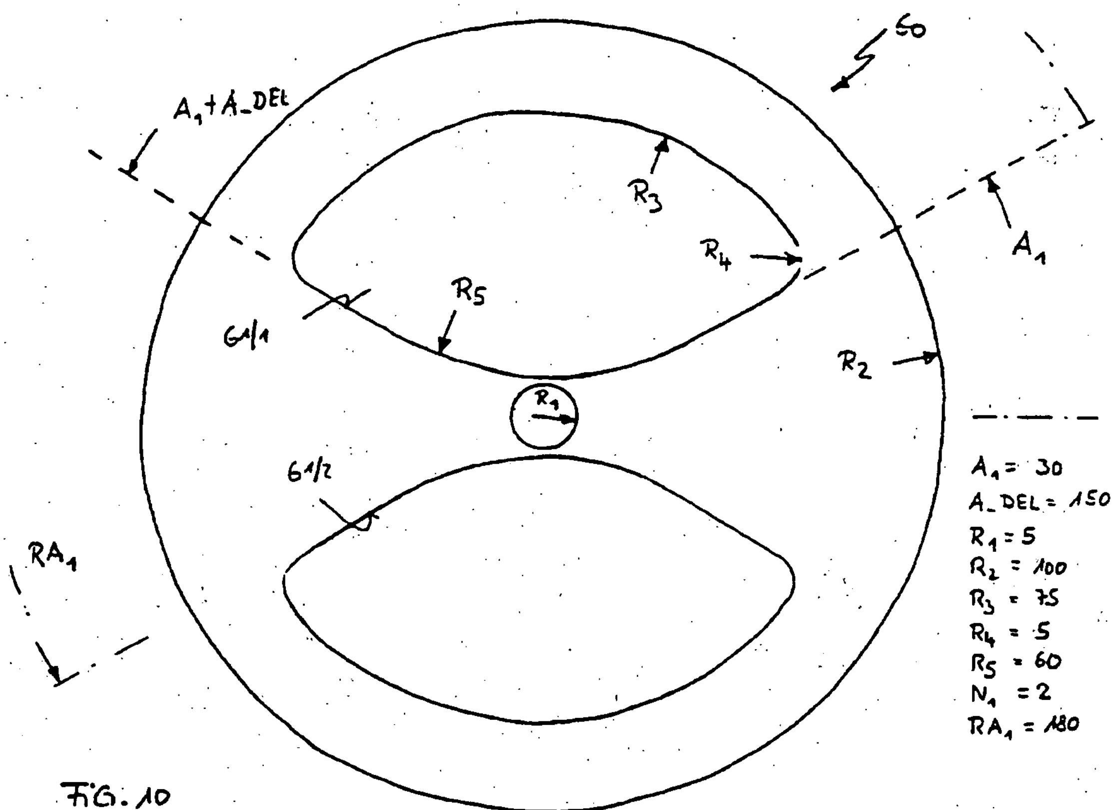

60
A1+A_DEL
R3
A1
R4
R5
61/1
R2
R1
61/2
RA1
A1 = 30
A_DEL = 150
R1 = 5
R2 = 100
R3 = 75
R4 = 5
R5 = 60
N1 = 2
RA1 = 180

FIG. 10

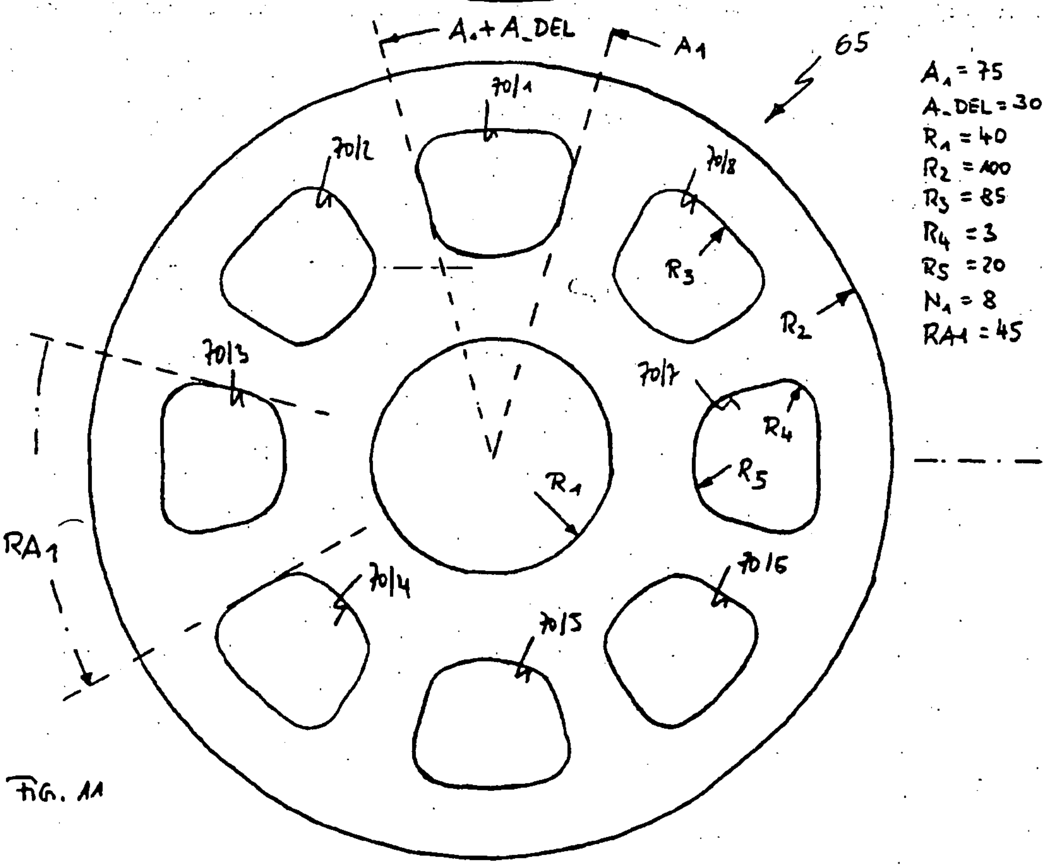

A1+A_DEL
A1
65
A1 = 75
A_DEL = 30
R1 = 40
R2 = 100
R3 = 85
R4 = 3
R5 = 20
N1 = 8
RA1 = 45
70/1
70/2
70/8
R3
R2
70/3
70/7
R4
R5
R1
RA1
70/4
70/5
70/6

FIG. 11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 10 8990

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	WO-A-8 803 290 (TRANSFORMERCAD INC.) * Page 23, lines 6-11; page 43, line 30 - page 44, line 2; page 58, lines 18-25; claims 1,39; figures 25,50,52,54 *	1,8	G 06 F 15/72
Y		2-7	
X	AUTOCAD RELEASE 10, REFERENCE MANUAL, September 1988, pages 121-124, A. Wheaton & Co. Ltd, Exeter, GB * Wole artcile *	8	
Y	IDEM	2-7	
A	COMPUTER GRAPHICS'81, 1981, pages 281-292; U. WEISSFLOG: "Graphic interactive appliction monitor (GIAM)" * Page 290; figure 5 *	1,8	
A	MACHINE DESIGN, vol. 59, no. 6, 26th March 1987, page 56, Cleveland, Ohio, US; "Touchpad increases CAD output" * Page 56 *		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 06 F 15/72
G 06 F 3/033

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-01-1990	GUINGALE A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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